A VERSATILE, LOW-COST STREAM GAGING SYSTEM

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A Versatile, Low-Cost, Stream Gaging System

(A final report on Contract No. 16-105 between the Rocky Mountain Forest and Range Experiment Station, U. S. Forest Service, and Colorado State University.)[1/]

The gaging system to be described is in the "de-bugging" and final testing stage; another year of time and financing will be required to reach the operational stage. Reported here is the present status of development and an appraisal of work remaining.

The system is intended as a substitute for weirs and flumes where costs of these are too high to be justified by informational needs. Its potential as a weir substitute is indicated by Figure 1. The system is inexpensive relative to usual weir cost. If servicing is to be weekly, on-site equipment cost should be less than $500 for a stream having peak discharges of 75 cfs or less. For larger streams or less frequent servicing, cost will increase moderately. Need to gage under freezing temperatures or where vandalism is to be expected will have a similar consequence. Cost of materials for gaging a stream averaging 10 cfs is estimated at not over $20 per week; further research and bulk purchases may reduce this. After satisfaction of needs at one site, the equipment may be readily moved to a new location by primitive means or helicopter.

1/ Work here reported has been supported jointly by the Rocky Mountain Station under Contract No. 16-105 and by the Bureau of Reclamation, U. S. Department of the Interior, under Contract No. 14-06-D-5218.

A small laboratory facility will service 10 to 20 gages for an equipment investment of around $3500. Laboratory output will be stream hydrographs as well as flow volumes for any time period. Field tests to date indicate a realizable accuracy comparable to that of a good V-notch weir. Tests have been fairly extensive in time but limited to three mountain streams lightly sediment laden. Because the system does not require the cut-off wall of a weir, it will register surface flow only, whereas a weir may, more nearly and with luck, measure total yield. This disadvantage can be minimized by choice of the gaging site.

The gaging system is a unique development of the tracer method of instantaneous gaging of stream discharge; a method long and widely used in France and Switzerland and coming into use in the United States and other countries. In the system here described, a fluorescent dye (Rhodamine WT) is the tracer. In the concentration required (a few parts per billion), this dye is non-toxic and invisible. It disappears quickly (but not too quickly) by decay and adsorption. Essentials of the system are described below; details follow on pages 5 to 11.

Into a chosen stream reach, a dye solution of known concentration is injected at a known and constant rate - about 6 cc per minute for a stream flowing 10 cfs. At a point downstream where mixing is complete, a small flow is diverted from the stream through a bank-mounted sampler. Here the dye-dosed water contacts a continuous, clock-driven strip of gelatine-coated film, like 35 mm photographic film without the photo-sensitive hallides. By chemical affinity, the gelatine adsorbs dye in quantity per unit area proportional to dye concentration in the stream

and thus inversely proportional to the discharge rate of the stream. After exposure, and with allowance for drying time, the film is automatically re-spooled.

At a chosen time interval (we have chosen a week but longer intervals should be feasible), the exposed section is removed and taken to the laboratory for analysis. Here it is drawn by clock-work through an especially modified fluorometer where it is scanned, the quantity of dye per unit area of film sensed by its fluorescence, the quantity transduced to millivolts, and a chart trace produced. This trace is the stream hydrograph. Only simple calibration at one or two points is needed to allow reading in terms of cfs. Different methods of calibration are possible; selection of the best one has not yet been made. Periodic volumes of flow may be compiled from the trace; automatic, electronic compilation should be readily possible with an additional equipment investment.

Besides measuring rate and volume of streamflow, the system or the sampler alone has potential for other uses. The sampler, combined with a simple means of slug injection of dye, should be a low cost convenience to measurements of flow velocities in either surface or underground streams and to tracing paths of the latter. For surface streams, combined velocity and discharge measurements can yield the effective cross-section of channels; a parameter of interest in investigations of channel hydraulics, including carrying capacity.

Remaining work on the system is envisioned to be as follows:

1. Refinement of fluorometer modification and field equipment.

2. Selection and development of best means of calibrating output trace of fluorometer.
3. Further testing of all individual items of equipment and procedures.
4. Further testing of complete systems on streams differing in characteristics including that of suspended sediment.

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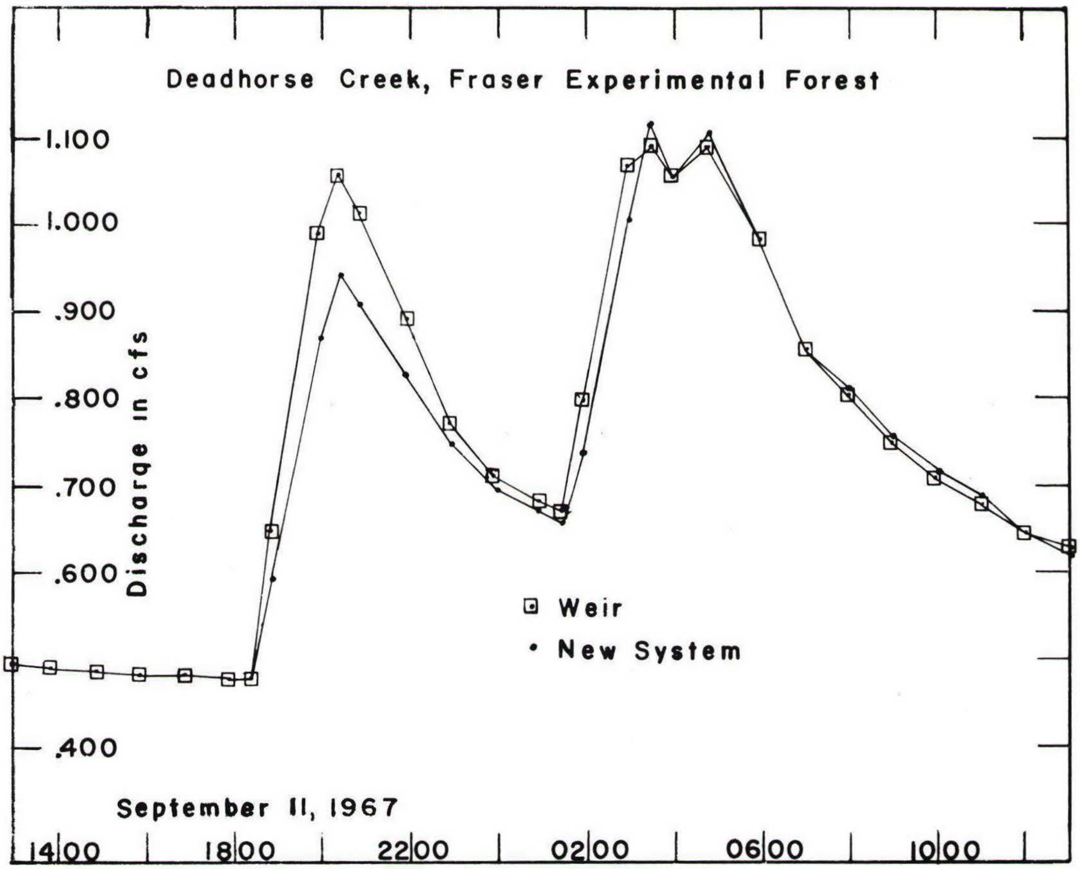

Figure 1. A rain-caused stream rise simultaneously recorded by a conventional, 120°V-notch weir gaging station and by the new gaging system. Agreement failure near peak of first rise is believed due largely to the time lag in the new system. This can be reduced.

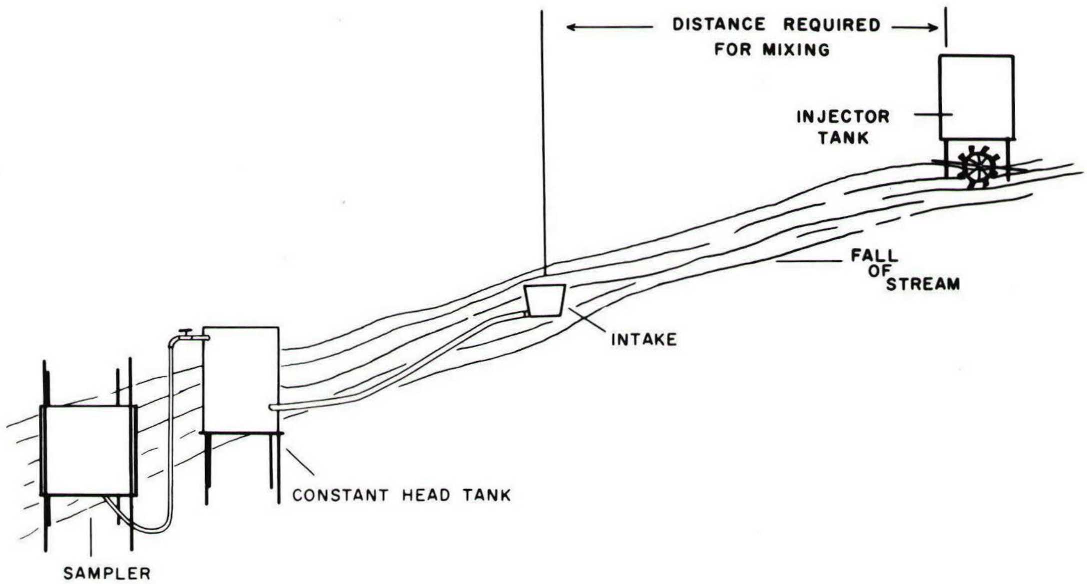

Figure 2. Dye injector is mounted over stream or on stream bank. At a downstream point where mixing is complete, a small flow is hose-diverted through a constant head tank and the sampler.

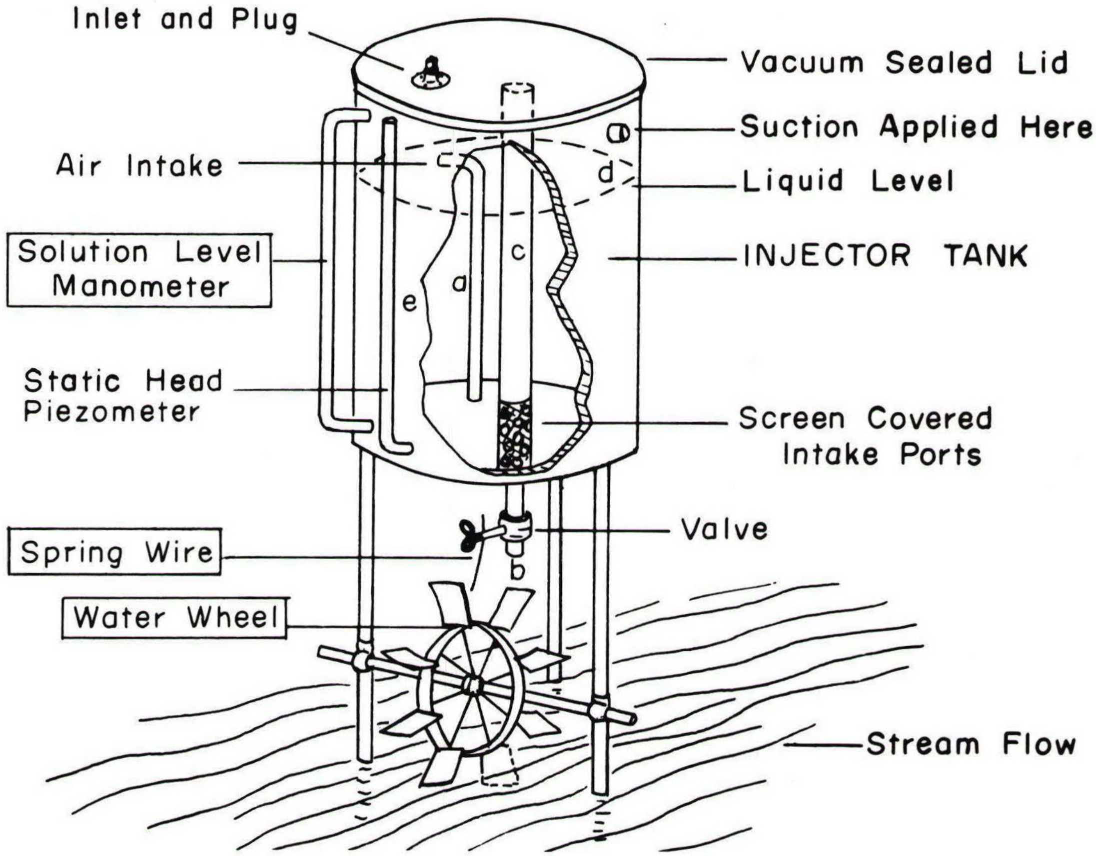

Figure 3. Injector consists of a tank with fittings appropriate to the maintenance of a constant liquid head on a small orifice at b, and to filtration of the dye solution in its path to the orifice. The water wheel imparts periodic vibration to the orifice appurtenance, a necessity for constant discharge. In a bank-mounted installation, a battery powered vibrator is substituted for the water wheel.

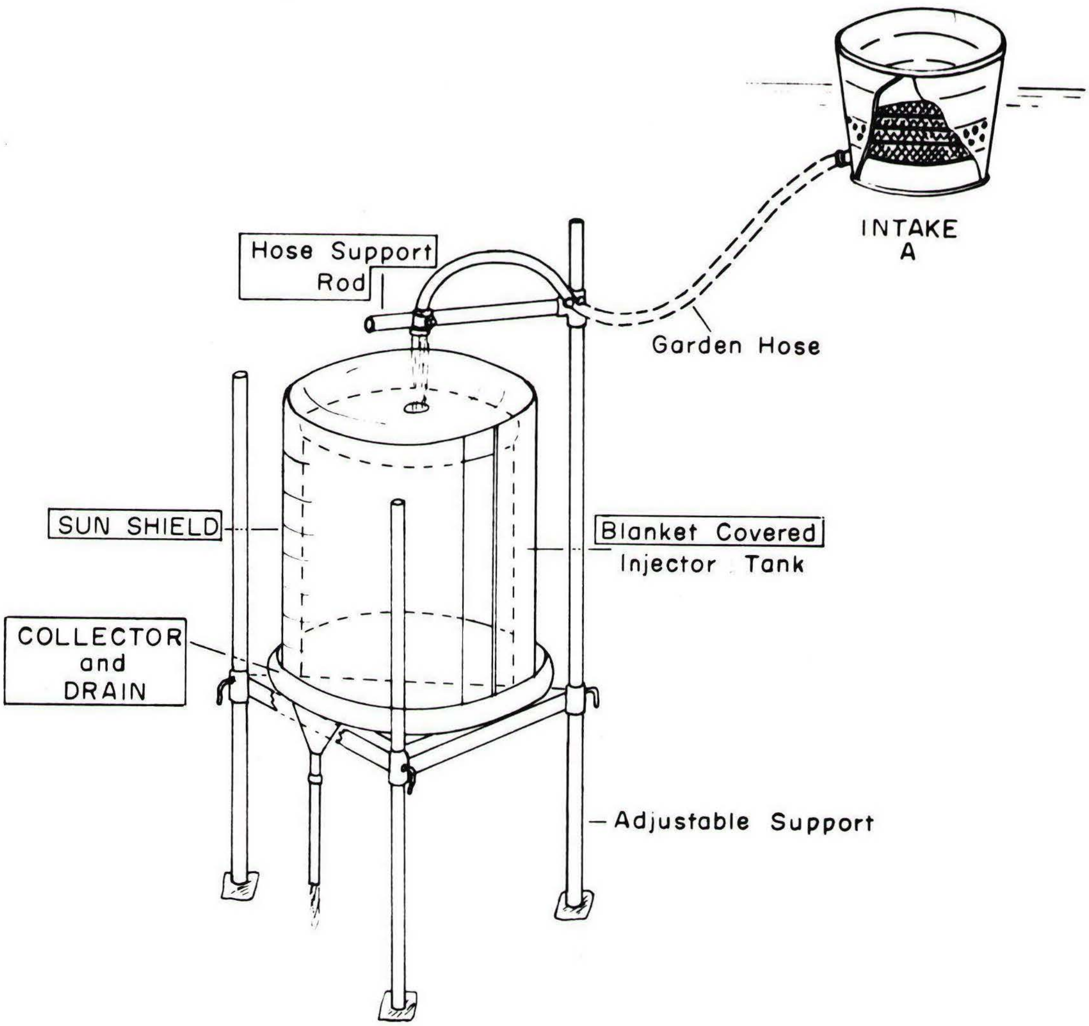

Figure 4. If the injector tank is warmed too rapidly by ambient conditions, air expansion within causes increased head on the orifice and inconstancy of discharge. Protection against rapid warming is provided by the sun shield and a gravity flow of stream water over the tank.

Figure 5. Injector mounted over stream, sun shield removed and stream of cooling water diverted.

Figure 6. Injector mounted on bank of a larger stream. Dye flows through rigid conduit into stream.

Figure 7. Sampler consists essentially of a battery powered, film feed system and a "bath" in which film is exposed to the dye-dosed water. A constant head tank insures constant flow into sampler regardless of stream stage.

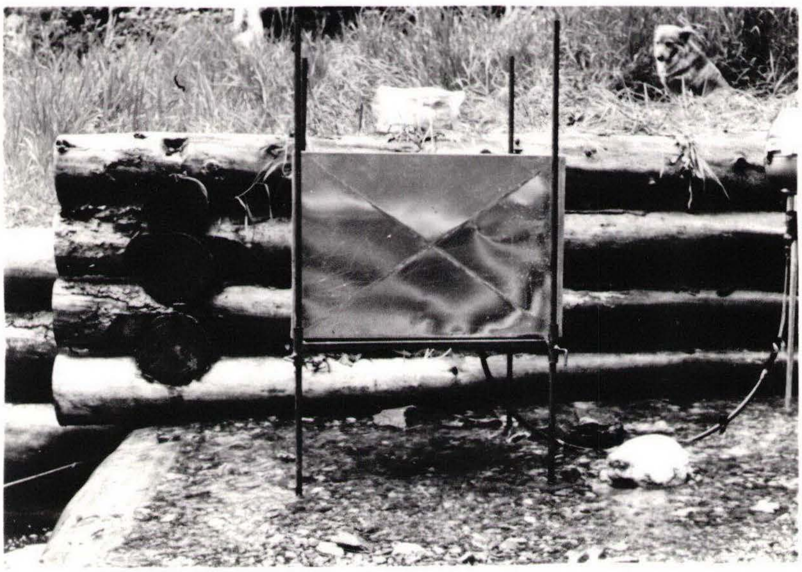

Figure 8. While in operation, the sampler is shielded by a bottomless aluminum box against sunlight heating and against possible photochemical degradation of the gelatine adsorbed dye. An inner, air-tight cover allows use of a dessicant to insure drying of film before re-spooling.

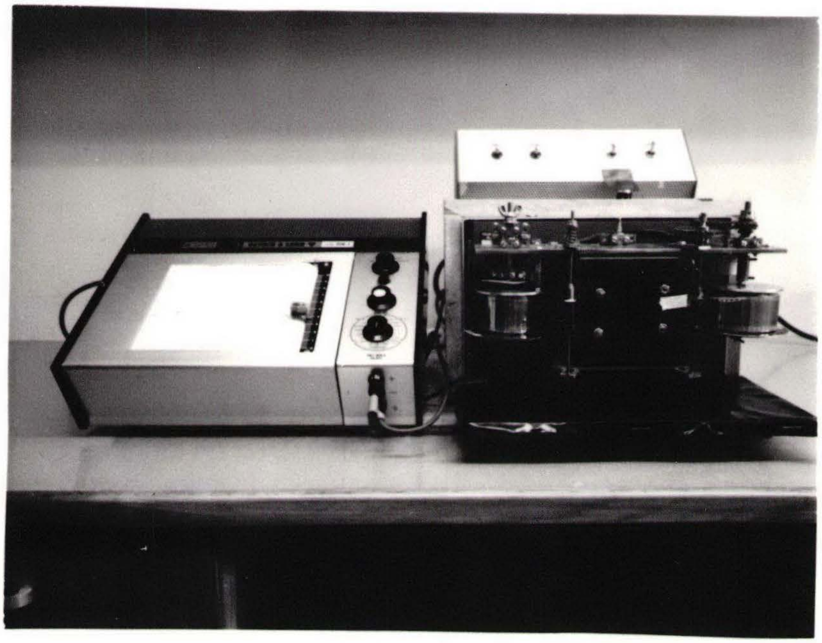

Figure 9. The film is drawn by an electric timing motor through an especially modified fluorometer for automatic analysis of the dye content. The fluorometer output is traced on a strip chart by a servo-potentiometer. The rythmic, smaller fluctuations are caused by faults in the sampler where the film is exposed to the dye. They can be eliminated by equipment refinement. The larger scale variation in trace height is a true representation of diurnal fluctuation on the stream.